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GRAPE SYRUP

PRELIMINARY REPORT

BY
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I. INTRODUCTION

Sugar in Grapes.—Ripe grapes, especially those grown in California, are so sweet that their use as a source of sugar is naturally suggested. Most of the proposals to utilize them for this purpose, however, are based on a misunderstanding of the nature of the raw material and of the proposed products.

Various Kinds of Sugar.—Sugar, in the common use of the word, means dry, granulated or crystallized *sucrose.* This is only one of several sugars and one which cannot be produced from grapes because they contain none. Grapes contain however, two sugars, glucose and levulose, both of which are wholesome foods. The sweetness of glucose is less than that of sucrose, but that of levulose is greater. The mixture known as *grape sugar** has about the same degree of sweetness as sucrose, usually called *cane sugar.*

At present, no method is known by which the sugar in grapes can be given the dry, granulated texture required in commercial sugar. A sugar syrup, however, can be made from grapes and their sweetness utilized in this way.

Sugar Syrups.—Sweet syrups are of various kinds which it is necessary to distinguish and understand before attempting the manufacture of any of them.

A syrup can be made by dissolving pure cane sugar in a little water. Such a syrup is that used in canning. It is perfectly neutral in flavor, that is, it has no taste but that of sweetness. Similar neutral syrups can be made in the same way from pure glucose or other sugar.

Syrups of varying flavors, on the other hand, can be made from impure cane or other sugars. The syrups commonly sold, such as maple syrup, sorghum syrup, corn syrup, "golden syrup," and molasses are of this character. The flavors may be agreeable or disagreeable, according to the nature of the impurities to which they are due.

*What is often known in commerce as "grape sugar" is simply glucose and is made from corn or other starchy material. It is less sweet than real grape sugar.

These impurities, moreover, may be wholesome, unwholesome, or indifferent.

If the flavors are agreeable and the impurities harmless the syrup may be preferable for some purposes to pure, neutral cane sugar syrup. This is the case for some tastes with maple syrup and others, and when a market is established for such syrups, they command a higher price than the neutral syrups with which they do not compete. On the other hand, if the flavors are not agreeable, the syrups must compete with neutral syrups and this they can do successfully only by being sold at a lower price.

Grape Syrup.—To manufacture and market grape syrup successfully, we must therefore attain one of the following results:

1. Produce a neutral syrup that can be sold profitably at the same price as cane sugar syrup.

2. Produce a syrup of inferior quality that can be sold profitably at a lower price than cane sugar syrup.

3. Produce a syrup of superior quality that will attract consumers at a price higher than that of ordinary cane syrup.

Preliminary tests indicate that probably the first two results cannot be obtained under ordinary conditions of the market. To raise grapes profitably they should bring at least $15 per ton and this would represent a cost of close to 4 cents per pound for the sugar they contain. To this cost must be added the expenses of manufacture which would bring the cost of the finished syrup higher than that ordinarily ruling for cane sugar syrup. With the present high cost of cane sugar, a neutral grape syrup might be sold for a price that would make it possible to pay $15 or more per ton to the growers. Grapes this year, however, are bringing much more than this for other purposes, and if the price of grapes falls, it is probable that that of sugar will fall in proportion.

The only chance of making grape syrup profitably as a permanent industry, therefore, seems to be to obtain a product that will command a price higher than that of the ordinary cheap syrups. It can do this only if it possesses qualities that are preferred by consumers. It must, in other words, be sold on a basis similar to that of maple syrup.

The more distinct the flavor, providing it is agreeable, the more likely it is to find and keep a permanent profitable market. It would seem a mistake, therefore, to attempt to make a syrup of neutral flavor to compete with cane syrup.

Nature of the Investigations.—The two problems to be solved than are:

(1) Can a grape syrup be made that will be bought for its special qualities? and

(2) Can it be produced and sold at prices which will attract the consumer and pay the grape grower?

The production of grape syrup involves: (1) growing the grapes, (2) extracting the juice, (3) concentrating the syrup.

No changes are necessary in growing the grapes. Cull table grapes, second-crop raisin grapes, and in case of the prohibition of wine-making, wine grapes are the available raw material.

Wineries are already equipped for extracting the juice for wine-making purposes and would require few changes or additions to prepare juice for syrup making.

Condensers for making the grape syrup needed in sweet wine already exist in many wineries. Their output, however, is small and the product not well suited for the object in view. They would have to be considerably modified and expanded to be of much use in making table syrup. The beet-sugar factories, however, have a very large capacity, sufficient to handle all the grapes grown in California and could be adapted to the manufacture of grape syrup with little change. As they are idle for several months in the year, they could easily concentrate all the grape juice that would be available if this juice could be obtained during the proper season of the year. This season is the spring and summer when they are not busy with beets.

One of the main problems, therefore, is the keeping and storage of the juice from the vintage to the spring.

II. GRAPE JUICE

Amount of Sugar in the Grapes.—The riper the grapes the more sugar they contain and the more syrup they will yield. Cull table grapes at the beginning of the season may show a sugar content as low as 15% (Balling degrees), towards the end, as high as 25%. Wine grapes are usually gathered when they show 22% to 23%, but may be gathered as low as 19% or as high as 27%.

One hundred gallons of juice at 23° Balling contains close to 190 pounds of grape sugar; at 19° Balling, only about 157 pounds; but at 27° Balling, about 223 pounds.

Separating the Juice.—The volume of one ton of stemmed grapes at 23° Balling is 29 cubic feet or 219 gallons. This consists of skins, seeds, and juice in varying proportions. The average volume of juice actually present may be taken as about 190 gallons, but it will vary from 175 to 210, according to the variety and the develop-

ment of the berry. There is a little more than this in grapes below, and a little less in grapes above 23° Balling. The difference is about 1 gallon per ton for each degree Balling.

Wineries, by crushing and pressing the grapes, can separate more or less of this juice from the solid parts of the grapes. The average volume of juice extracted in this way from unfermented grapes will not much exceed 150 gallons per ton. The remainder, about one-fifth of the whole, is retained by the pomace (solid matter). By repressing or by using more powerful presses a little more juice can be obtained but the cost is high. By leaching with hot water nearly all the juice can be obtained but in a more or less diluted form.

Extracting the Pomace.—The juice remaining in the pomace can be separated by the use of water in several ways. For example: (1) by sprinkling hot water on top of the pomace in a tall vat open below. The water dripping through the pomace will leach out a large part of the remaining sugar; (2) by allowing hot water to stand on the pomace in a vat for several hours and then drawing off the liquid and pressing the pomace again; (3) by connecting together a battery of several vats filled with pomace and passing a stream of water downwards through the series. The juice is extracted in this method by diffusion and displacement.

In all these methods the water must be very hot to destroy the power of the pulp cells to retain the juice. The first method is the simplest but the extraction is imperfect; the second requires repressing and is laborious; the third is the most efficient, but requires expensive equipment.

A laboratory test of the second method with 90 pounds of grapes gave the following results:

YIELD PER TON OF GRAPES

First pressing	136.00 gals. at 18° Balling
Second pressing (after application of hot water)	153.75 gals. at 7°.2 Balling
Total	289.75 gals. at 12°.27 Balling

Volume of 1 ton grapes at 18° Balling	223.5 gallons
Volume of juice present (calculated from weight of dry pomace)	214.4 gallons
Volume of recovered juice (reduced to 18° Balling)	197.5 gallons
Juice recovered, per cent of volume of grapes	88.4 per cent
Juice recovered, per cent of juice present	92.1 per cent
Pomace recovered, per cent of volume of grapes	11.6 per cent
Sugar in juice recovered (calculated)	291 pounds

Another test made with 35.2 pounds of Sultanina grapes of 23°.1 Balling, gave the following results:

YIELD PER TON OF GRAPES

	Per cent of volume of grapes
First pressing, 137 gallons at 23°.1	62.7
Second pressing, 51.3 gallons (reduced to 23°.1)	23.4
Third pressing, 16.4 gallons (reduced to 23°.1)	7.5
Total: 204.7 gallons (reduced to 23°.1)	93.6
Sugar in juice recovered (calculated)	391 pounds

Preservation of the Juice.—Grapes, even if carefully gathered and handled, will keep in good condition at most for only a few days. The juice, however carefully handled, will commence to ferment in a few hours after extraction. Most vineyards are so situated that the grapes can be brought in good condition to the winery, but once there they must be crushed quickly or they will spoil. As soon as the juice is extracted it must be made into syrup or preserved in some way.

As the vintage in any one locality lasts only four or five weeks, it would be impracticable to make the syrup as fast as the grapes were harvested. Some means of preserving the juice for several months, preferably 8 or 10, is therefore needed.

The only method at present known that seems practicable is the use of sulfurous acid (SO_2).

Amount of Sulfurous acid Needed.—Preliminary experiments demonstrated that liquefied sulfurous acid or a water solution of sulfurous acid were the forms most suited for this purpose. Fumes of burning sulfur are hard to control and sulfites leave too much potash or other base in the product. Sulfurous acid can be completely removed.

Tests were made on small laboratory samples (500 c.c.) of juice and on larger lots in 25 and 50 gallon barrels. Sulfurous acid was added in amounts varying from 300 to 2000 milligrams per liter. This corresponds to .03% to 0.2%.

All samples with 1000 milligrams or less fermented within a few weeks. The sample with 1250 milligrams kept perfectly for two months, when it was used. Fifty gallons in a barrel treated with 2000 milligrams kept from September until July of the following year. The large lots were stored in a shed where the temperature varied greatly and was often very hot. It seems probable, therefore, that 1500 milligrams of sulfurous acid per liter would be sufficient to preserve grape juice for ten months under any ordinary condi-

tions. This corresponds to 1.25 pounds of liquid sulfurous acid or 2.5 gallons of 6 per cent sulfurous acid solution to 100 gallons of juice (= 0.15% SO_2).

It has been found that the riper the grapes, the more sulfurous acid is necessary for preservation. The presence of moldy or other spoiled grapes has a similar effect.

Storage of Treated Juice.—Juice containing sulfurous acid should not remain in contact with any metal. It can be stored in barrels or other wooden vessels. These should be sterilized with steam and kept sulfured while empty. When containing juice, they should be completely filled and not bunged too tight. If only partially filled, sulfurous acid will be lost by evaporation from the surface and if the bungs are driven too tight, the barrels may explode if fermentation starts.

The filled barrels should be watched closely and on the first signs of fermentation treated with a new dose of sulfurous acid, about 1000 milligrams per liter; that is, 1¾ gallons 6 per cent sulfurous acid solution per 100 gallons.

If the filled barrels are to be stored for some time they should be placed so that the clear juice can be drawn off after the sediment settles. They should be wedged firmly to prevent movements of the liquid and kept in as even and cool a temperature as is available.

Transporting the Juice.—After storing, a more or less bulky sediment will be formed, equal to about 5% of the total volume of the juice. For shipping, the clear juice should be carefully drawn off the sediment into clean sterilized barrels. The racking should be done with as little disturbance of the liquid as possible and as little exposure to the air. Care in storing and racking facilitates clearing at the syrup factory.

III. MANUFACTURE OF THE SYRUP

Clearing the Juice.—Sulfited juice after standing and careful racking is usually clear. If not clear when it arrives at the factory it must be filtered or fined (clarified) before concentration.

If the juice is only moderately cloudy, it can be clarified with casein; if very cloudy, a mixture of casein and Spanish Clay is better. Both methods were used successfully in our experiments.

Commercial casein free from bad odors and T. P. (technically pure) ammonia were mixed in the proportion of 1 pound of the former to ¼ pint of the latter. These were placed with 1 quart of water in a kettle and allowed to stand about an hour to soften the casein. Two

gallons of water was then added and boiled and stirred until there was practically no smell of ammonia and then enough water added to bring the total volume to 4 gallons. This gives a 3%-solution of casein, of which three gallons is sufficient for 100 gallons of juice.

Spanish Clay was mixed with water at the rate of one pound to one gallon of water. The mixing must be continued until a thin homogeneous mud is formed, free from lumps. A convenient method is to place the clay and water in a small barrel which is rotated lengthwise by means of a pulley on a shaft passed through it short diameter. From 5 to 10 gallons of this clay mixture is used for 100 gallons of juice.

The clarifying liquids are added slowly to the juice with constant stirring or pumping over. The juice is then boiled, allowed to stand from 12 to 18 hours, and the clear juice drawn off. The sediment can be filtered.

Clarifying is most conveniently done in connection with the removal of the sulfurous acid, as described in the next paragraph. After adding the clarifying material, the desulfiting current of steam is passed through the juice. The casein, besides clearing, helps to decolorize the juice.

Removal of the Sulfurous Acid.—The finished syrup must contain practically no sulfurous acid. That contained in the juice therefore must be removed during the process of manufacture.

Many methods were tested for this purpose, but all failed more or less except one. Boiling down the juice to a syrup removed an amount about in the ratio of the concentration; that is, the syrup contained about the same per cent of sulfurous acid as the juice from which it was made. Passing streams of various gases through the juice also gave imperfect results. A stream of compressed air passed through the juice which was kept at 140 to 180° F. removed the sulfurous acid with fair rapidity but not completely.

A thoroughly satisfactory method was found in passing a current of steam through the boiling juice. The steam was conducted into the cold juice held by a wooden container until the juice reached the boiling point. The steam was then passed rapidly through the boiling juice until all the sulfurous acid was removed, which required from 30 to 35 minutes in the 5-gallon lots used. All contact with metals should be avoided in this process.

Decolorization.—If a light-colored syrup is to be produced, the juice of red grapes and probably also of white grapes will have to be decolorized. Of the methods tested, treatment with bone black, gave the best results. Bone black free from objectionable odors and

flavors and containing little or no metallic oxides or carbonates should be chosen and preferably washed with acid before use.

In our small-scale tests, powdered bone black was found best. In commercial work, probably the coarse bone black used in the usual decolorizing "towers" of sugar factories would be better.

In the manufacture of cane sugar, the juice is concentrated to from 45° to 60° Brix before decolorization, to reduce the volume to be handled. A similar practice would be convenient with grape juice.

The bone black in time will lose its decolorizing power, but may be "revivified" by mixing with a small amount of sodium carbonate (soda ash) and heating in a closed retort to carbonize the organic matter absorbed by the bone black. The bone black is then leached with water to remove the sodium salts. An amber colored syrup can be produced from light colored juice without the use of bone black.

Deacidification.—Juice from ripe grapes contains, on the average, about 0.7% of acid expressed as tartaric acid. This is mostly cream of tartar ($KHC_4H_4O_6$) and some tartaric acid ($H_2C_4H_4O_6$). If the acidity is not reduced it will cause the syrup to be too sour for most tastes. The best material found for reducing the acidity was calcium carbonate. An excess does no harm as both the calcium carbonate added and the calcium tartrate formed are insoluble and can be removed. A part of the calcium salts does not precipitate immediately but gradually forms a cloudiness in the syrup on standing but can be then removed by decantation or filtration. Sodium carbonate (Na_2CO_3) or caustic potash (KOH) leave soluble salts in the syrup, and lime (CaO) in excess spoils it.

Decolorization is more rapid and requires less bone black while the juice is acid. It should therefore precede deacidification. If it follows deacidification, the alkaline salts in the bone black will make the juice alkaline and this cannot then be decolorized.

Concentration of the Juice.—In reducing the juice to a syrup, the object is to obtain a product of the desired concentration with as little change in flavor and color as possible.

If we evaporate the juice by heating in an open vessel, a comparatively high temperature is necessary which results in destroying much of the grape flavor and in giving a cooked taste and dark color.

In the Waterhouse process, high temperatures are eliminated. The process consists essentially of evaporating the juice on strips of cloth exposed to the sun and dry air. The resulting syrup is dark colored and has a raisin or cooked taste. This indicates that the action of the oxygen of the air is as harmful as that of high temperatures.

The usual method of making syrup on an industrial scale is by means of evaporation in a partial vacuum. This method makes it possible to concentrate the juice at a lower temperature than boiling in an open vessel and removes most of the air in contact with the juice during the process.

The vacuum pans used in this method are of various types, some of "quintuple" or "triple effect," and continuous operation, in which the process is rapid and consequently the time of exposure of the juice to heat short. In other types the evaporation is discontinuous and the concentration takes place in a single vacuum pan. The time of exposure to heat in the latter types is much longer.

A small vacuum pan of the latter type was used in the experiments. It was operated with a vacuum of 24 inches and steam of 30 pounds' pressure. Under these conditions, concentration required about 2½ hours. The higher the vacuum and the more rapid the evaporation, especially during the last stages of concentration the lighter colored and better flavored the syrup. It seems probable, therefore, that regular triple or quintuple vacuum pans of sugar factories would yield a syrup of better quality than that obtained in our experiments.

The care taken to avoid prolonged contact of the sulfited juice with metal is not necessary during concentration because the sulfurous acid has been eliminated and all other acids much reduced.

All these processes of concentration are based on the fact that sugar syrup has a higher boiling point than that of pure water. Therefore, when we raise the temperature of the juice to the boiling point of water (whether at air pressure or in a partial vacuum), the water evaporates from the juice and leaves the syrup.

Other processes are based on the fact that sugar syrup has a lower freezing point than water. Therefore, when we lower the temperature of the juice to the freezing point of water or a little lower, the water is precipitated or separated as a solid (ice) and can be removed, leaving the syrup. These processes offer the most promising means of obtaining a syrup retaining the high flavor, light color, and other qualities of the juice as little changed as possible. They are not used commercially in California and were not tested in the present investigation.

Degree of Concentration.—If the syrup is concentrated to above 65° Balling, part of the glucose will crystallize on standing. If the syrup is much below 65° Balling, it will appear thin. The finished syrup therefore should be as near this point as possible. Syrup of this concentration will show 62° as it comes hot from the evaporating pan.

Settling the Syrup.—As the syrup comes from the pan, it contains an excess of calcium tartrate. This is solid and will settle out in about two weeks if the syrup is left in large vats. The clear syrup can then be drawn off and placed in containers for sale. The syrup in the lees can be recovered by means of a filter press. The "cake" from the press can then be washed, the washings concentrated to syrup, and the solid matter dried and sold to cream of tartar factories.

Packing.—The finished syrup can now be placed in the final containers. These may be cans, bottles, or barrels. Cans are perhaps to be preferred as they are most convenient. The syrup has no effect on the metal.

Sterilizing.—The syrup does not spoil easily, but in time may mold or ferment unless sterilized. If packed in barrels, these should be sterilized and the juice run in at a temperature between 140° F and 160° F. If placed in cans or bottles these should be sterilized 25 minutes for quarts, to 35 minutes for gallons, at 155° F to 160°F. Longer heating or higher temperatures darken the syrup. The sterilization is carried out exactly as with fruit.

IV. OUTLINE OF METHOD

(Based on Experimental Work)

1. Use ripe grapes, preferably 25° Balling or higher.

2. Crush and press as soon after picking as possible. Use ordinary winery equipment.

3. Extract the juice from the pomace by progressive washing with boiling water and steam, and two supplementary pressings. Mix the liquid from the first extraction with the undiluted juice and use the liquid from the last extraction for the first extraction of the next lot of pomace.

4. Add 1500 milligrams of sulfurous acid per liter to the juice and store in clean, completely filled and lightly bunged wooden tanks.

5. Rack from the sediment, avoiding contact with air and ship in wood to the sugar factory.

*6. Desulfite with steam (and clarify at the same time if necessary).

7. Decolorize with bone black if a very light colored juice is desired.

* It might be preferable in practice to desulfite the juice at the winery before shipping to the syrup factory. This could be done in open wooden vats with pressure steam. This would cause a partial concentration and reduction of about 50 per cent in volume which would decrease transportation charges. The removal of the sulfurous acid would also make it possible to ship the juice in metal containers.

8. Filter.
9. Deacidify with calcium carbonate.
10. Filter.
11. Concentrate to 65° Balling in triple-effect vacuum pans.
12. Allow to settle 2 weeks in clean tanks.
13. Pack in gallon, quart, or pint cans.
14. Pasteurize 25 to 35 minutes.
15. Cool in water.

V. SPECIAL SYRUPS

The experiments detailed above and the method suggested had for their object the production of a syrup as much like the syrups in common use as possible. These syrups are all neutral in flavor, low in acid, and light in color.

By omitting or moderating the deacidification, a syrup can be made with any desired amount of acidity.

By using certain processes which retain more or less the flavors of the grape, syrups of various high and agreeable flavors can be produced.

By using red grapes and omitting the decolorization, red and pink syrups of attractive color can be obtained.

By evaporating in open kettles after deacidification a dark syrup with a pleasing molasses flavor and suitable for table use is obtained.

These special syrups could be used in the preparation of sweet beverages, in ice creams, jams, and in cooking, and would undoubtedly be found useful and excellent by many.

VI. MARKETING THE SYRUP

The successful marketing of the syrup depends on finding consumers who are attracted by its quality and price.

To test the possibilities in this respect a quantity of syrup was placed on sale through the co-operation of a local grocer. It was put up in pint bottles and tins holding 13½ ounces. These were sold for 20 cents a tin and 25 cents a bottle, a price somewhat higher than that of ordinary cane or corn syrup at the time, but lower than that of good maple syrup.

Purchasers were asked to give their opinion on its quality, and the results were encouraging. Of sixty-five opinions given, 43 were favorable, 18 more or less unfavorable, and 4 non-committal. The following is a summary of these opinions:

SUMMARY OF OPINIONS

Very good, lovely, excellent, very nice	23
Good—no unfavorable comment	20
Disliked it—no specific criticism	5
Too sweet	2
Not sweet enough, too thin	6
Tastes cooked, burned, strong	6
Doubtful	4

Less than 8% of those reporting found it without merit. About 25% liked it, but found various defects. The remaining 66% found nothing to criticise and of these more than half praised it highly.

These reports are more favorable than could have been anticipated when we consider that grape syrup differs very considerably in flavor from all the syrups with which most people are familiar. A marked difference in the taste of a common article of food will nearly always give an unfavorable impression even if it is an agreeable difference.

The commonest criticism was that the syrup tasted cooked or burned. This taste, which a few liked, is due in part to the long heating necessary with the type of evaporator used. With the the continuous evaporators used in sugar factories it would be diminished or even eliminated.

The only other criticism that was made several times was that the syrup was too thin or not sweet enough. It is not quite so heavy as ordinary cane syrup and its slight acidity makes it taste less sweet. This it would be difficult to overcome. If all the acidity were removed, the color would be darkened and the cooked taste intensified. If it were made heavier it would be liable to solidify in the can. However, less than 10 per cent of the tasters found that these characteristics were defects and these characteristics, together with the special flavor of grapes, would be some of the qualities which would attract the special consumers upon which the syrup must depend for its market.

More detailed reports were received from a number of consumers. Some found the syrup very agreeable for table use when used on rice and mush, boiled or fried, or with hot cakes, corn bread, and biscuits.

Several tested the grape syrup in cooking and found it excellent in making cakes, cookies, corn bread, ginger bread, puddings, and pies. Cakes and cookies made with grape syrup remained moist longer than when made with ordinary sugar.

Excellent jams and fruit butters were made from dark colored fruits. Good results were obtained when grape syrup was substituted

for sugar at the rate of one cup of syrup for one of sugar. In jams made from light colored fruits the results were less satisfactory.

Attempts to use grape syrup in the preparation of jellies and marmalades were not successful.

Tests of the use of grape syrup in canning were encouraging. Certain fruits, such as loganberries, black cherries, and some peaches were as good when canned with grape syrup as with sugar. Apricots were improved in color, but the flavor was less fresh. Pears were darkened somewhat but the flavor was good. In these tests, cans in which only grape syrup was used were compared with cans in which only ordinary sugar was used. They indicate that a mixture of sugar and grape syrup in the ratio of 25% to 50% of the latter would give good results in nearly all cases.

VII. YIELDS AND COSTS

We can make an estimate of the amount of syrup that a ton of grapes should yield by using the following formula:

$$G = \frac{b \times s}{B \times S} \times g$$

where

$G =$ Gallons of syrup.
$b =$ Balling degree of juice.
$s =$ Specific gravity of juice.
$B =$ Balling degree of syrup.
$S =$ Specific gravity of syrup.
$g =$ Gallons of juice obtained from 1 ton of grapes.

If we assume 200 gallons as the average amount of juice obtainable by the methods described, this formula would give us for grapes of various degrees of ripeness the amounts of syrup of 65° Balling shown below.

YIELD OF SYRUP (65° BAL.) FROM ONE TON OF GRAPES AT VARIOUS DEGREES BALLING

(CALCULATED)

Balling of juice	Gallons of 65° syrup By formula	By 2½ times Balling
Juice of 18° Balling	45.0	45.0
Juice of 19° Balling	47.7	47.5
Juice of 20° Balling	50.4	50.0
Juice of 21° Balling	53.2	52.5
Juice of 22° Balling	56.0	55.0
Juice of 23° Balling	58.7	57.5
Juice of 24° Balling	61.5	60.0
Juice of 25° Balling	64.2	62.5

This indicates that if practically all the juice were extracted a ton of grapes would yield a number of gallons of 65° Balling syrup equal to 2½ times the Balling degree of the juice. The formula gives a higher figure for the sweeter grapes but as these grapes yield a smaller volume of juice a calculation made by multiplying the Balling degree by 2½ would be nearer the actual facts.

Experimental data corroborate these theoretical calculations.

YIELD OF SYRUP (65° BAL.) FROM ONE TON OF GRAPES

(FROM EXPERIMENTAL DATA)

Experiment	Gallons of juice	Per cent of volume of grapes	Balling per cent of juice	Gallons of syrup Found	Gallons of syrup Calculated
1	197.5	88.4	18.0	44.4	45.0
2	204.7	93.6	23.1	59.1	57.8

In Experiment 1 the volume of syrup is a little less than the calculated amount owing to incomplete extraction of the juice. In Experiment 2 the extraction was more nearly complete and the grapes seedless. Both these factors increase the volume of juice recovered and the volume of syrup is correspondingly a little higher than the calculated amount.

At the price of 20 cents for a 13½-ounce tin at which the syrup was retailed, a gallon would be worth, as bought by the consumer, $1.98, or, in round numbers, $2. A ton of grapes, therefore, would yield syrup of a final value of from $90 for grapes of 18° Balling to $135 for grapes of 25° Balling.

Whether this value is sufficient to yield a profit to the grower of the grapes, the manufacturer of the juice and syrup, and the retailer, is difficult to calculate from laboratory experiments. We can make an estimate, however, by basing our calculations on what is known regarding the cost of growing grapes, of extracting the juice at the wineries for wine making, of making syrup in the sugar factories, and of canning, together with experimental data on the special processes needed in the manufacture of grape syrup.

ESTIMATE OF COST OF PRODUCING GRAPE SYRUP

	Cost per gallon of syrup	
Grapes of 22° Balling at $17.50 per ton	$0.318	
		$0.318
Cost of operations at winery:		
Crushing, pressing, and storing at 1c per gal. of juice	.036	
Treatment with SO_2 at 1500 milligrams per liter	.027	
Transportation to sugar factory at 20c per 100 pounds	.073	
		.136
Cost of operations at sugar factory:		
Desulfiting at ½c per gal. of juice	.020	
Decolorizing at ½c per gal. of juice	.020	
Two filtrations at 1c per gal. of juice	.040	
Evaporation	.005	
Handling and pumping juice and syrup	.010	
		.095
Cost of canning—cans, boxes, pasteurization, labeling		.300
Commission of retailer, at 25%		.500
Total		$1.349

This table is an estimate of the actual cost of the manufacturing operations, which, subtracted from the retail price of $2 per gallon, leaves a balance of 65 cents per gallon. From this balance, is to be deducted all fixed charges such as interest on investment, depreciation of equipment, taxes, and insurance.

VIII. RAW MATERIAL

Under normal conditions of the past, there has been little grape material that could have been used for syrup. Under war prohibition of wine-making, there will be a large amount. In round numbers, about 500,000 tons of grapes have been absorbed by the wineries annually. The average price paid for these grapes has varied from something over $22 to about $15 per ton, according to locality and variety. If we assume an average price of $17.50, which is low, the grapes taken by the wineries represent a value to the growers of nearly $9,000,000 a year.

Approximately half of these grapes are produced in the raisin districts. These could be dried by methods well understood by the growers and would, under present conditions, probably find a market without much trouble, as inferior raisins for domestic consumption or for export for various purposes.

For the other half, or 250,000 tons, there is at present no prospect of any profitable use but the manufacture of syrup. If the whole

of this 250,000 tons of grapes were crushed and extracted, 50,000,000 gallons of juice would be obtained. This is about the total crushing and storage capacity of all the wineries in the state. To preserve all this juice there would be required 400 tons of liquid sulfurous acid.

The concentration of this juice would yield about 12,000,000 gallons of 65° Balling syrup, equivalent to about 40,000 tons of sugar. This amount could easily be handled by a few of the beet-sugar factories of the state during the months they are usually idle. The storage and shipment of this syrup would offer difficulties, but these might be solved by the use of the large number of oak casks made available by the closing of the distilleries.

The marketing of this syrup could be accomplished by governmental regulations which would encourage or enforce the use of grape syrup. Its use could be encouraged by a limitation on individual purchases of sugar and cane syrup and freedom of purchase of grape syrup. Its use could be enforced by obliging every fruit cannery to purchase a certain amount of grape syrup in connection with their purchases of sugar. These regulations could be enforced without hardship to manufacturer or consumer and would result not only in saving the grape grower from ruin but in saving a large amount of food which would otherwise be lost.

SUMMARY AND CONCLUSIONS

About 250,000 tons of wine and table grapes cannot be used next year in the usual way.

This represents a value of the raw material of over $4,000,000, and of about twice this amount in the manufactured state as wine, etc.

Their loss would involve the ruin of thousands of grape growers.

If they were made into grape syrup the product saved would be equivalent to over 40,000 tons of sugar of a present value of nearly $8,000,000.

Investigation has shown that a grape syrup can be made which is wholesome, attractive, and suitable for table use, cooking, the making of jams, and fruit butters, and for the canning of most of our fruits.

Most of the equipment necessary for making this syrup already exists in the wineries and beet-sugar factories of the state and what is lacking could be easily obtained.

The marketing of this large quantity of a new product could be successfully done only if many fruit canneries could be induced to use a certain quantity of grape syrup during the season of 1920. This could probably be done only by suitable governmental regulation.

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